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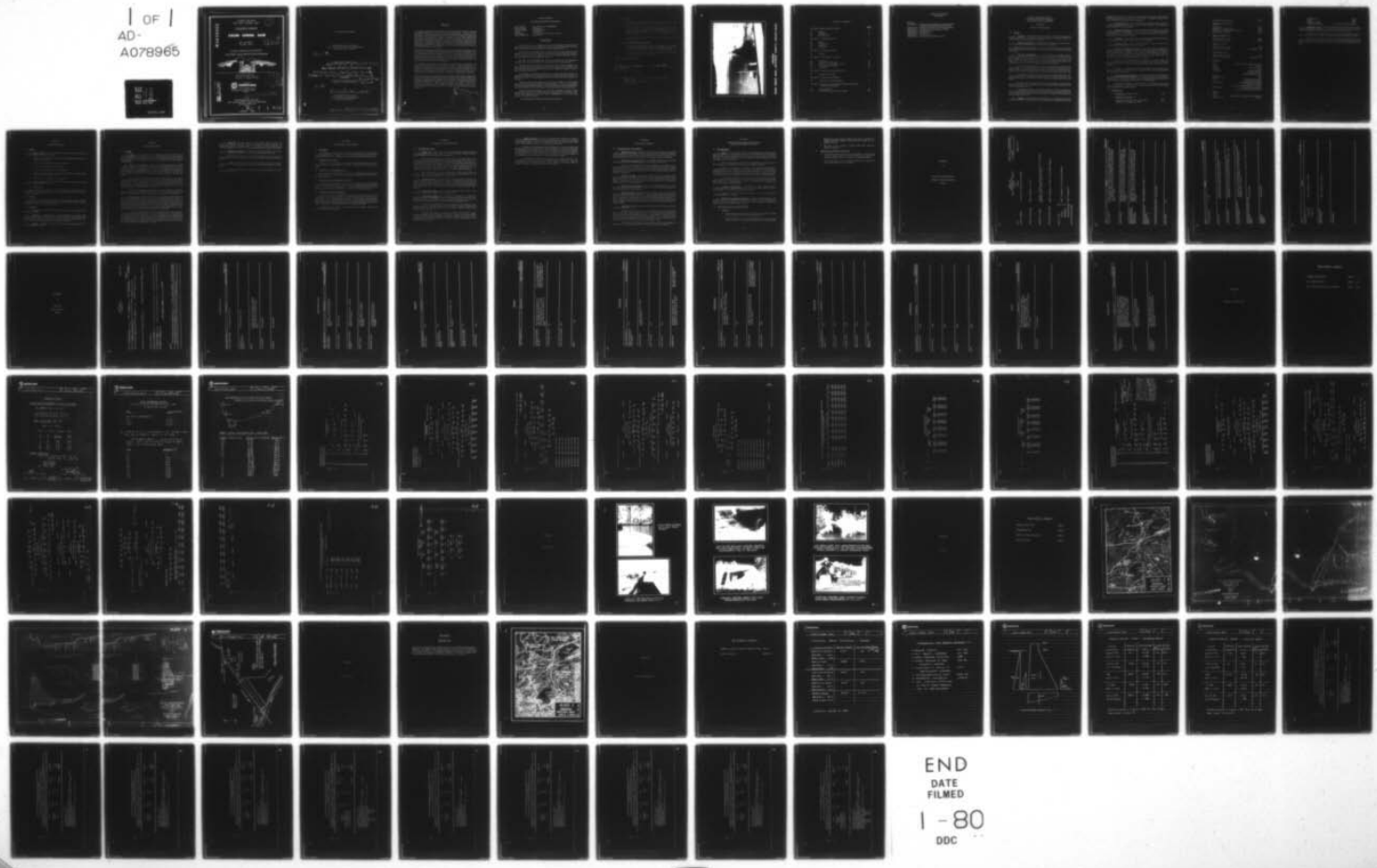

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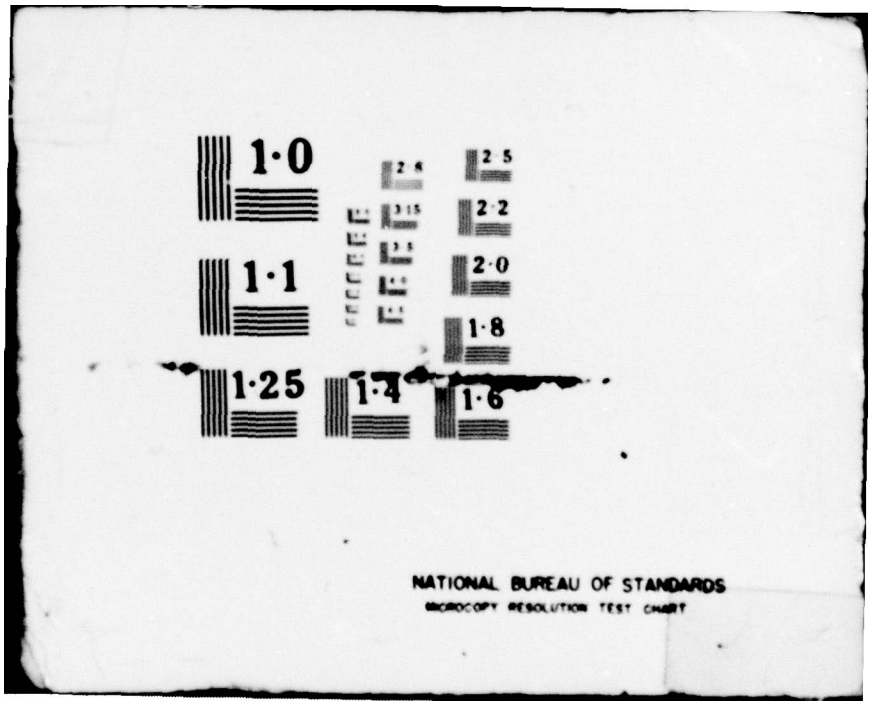
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DELAWARE RIVER BASIN
CRUM CREEK, DELAWARE COUNTY

PENNSYLVANIA

CRUM CREEK DAM

NDI - PA 00350
PA DER 23-20

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared By
O'BRIEN & GERE
Justin & Courtney Division
PHILADELPHIA, PENNSYLVANIA
19103

FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

AUGUST 1979

DELAWARE RIVER BASIN

Name of Dam: Crum Creek Dam
County & State: Delaware County, Pennsylvania
Inventory Number: PA00350

(11) Aug 79

PHASE I INSPECTION REPORT
(6) NATIONAL DAM SAFETY PROGRAM, Crum Creek Dam (NDI-PA-00350, PA-DER-23-20), Delaware River Basin, Crum Creek, Delaware County, Pennsylvania, Phase I Inspection Report.

Prepared by:

O'BRIEN & GERE ENGINEERS, INC
JUSTIN & COURTNEY DIVISION

(12) 92

For

(15) DACW 31-79-C-0020

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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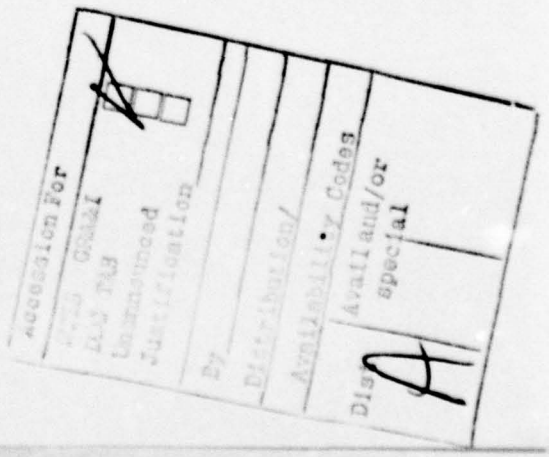
PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.



PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Crum Creek Dam ID #PA00350
State Located:	Pennsylvania
County Located:	Delaware County
Stream	Crum Creek
Coordinates:	Latitude 39^{o} 55.5', Longitude 75^{o} 22.0'
Date of Inspection:	June 13, 1979

ASSESSMENT

Crum Creek Dam is a masonry gravity structure (cyclopean concrete) about 610 feet long and 25 feet high. A 210-foot long ungated overflow spillway is located along the length of the dam about 80 feet from the right abutment.

The dam forms a reservoir with a surface area of 27.5 acres and a storage capacity of 282 acre-feet at normal pool. Maximum storage capacity (Elevation 117.0) is about 670 acre-feet. Based on the maximum height and storage capacity, the dam is classified in the "Small" size category.

The dam and impoundment are owned and operated by the Philadelphia Suburban Water Company; the facility is operated as a water supply reservoir.

The dam, which is classified as "High" hazard, has a Spillway Design Flood (SDF) equal to the Probable Maximum Flood (PMF). A review of the results of the hydrologic and hydraulic analyses indicates that the spillway is capable of passing about 23 percent of the PMF.

The spillway is classified as "Inadequate" for passing the PMF; however, the spillway is not considered "Seriously Inadequate" since the hazard potential due to a failure of the dam is not significantly greater than the hazard without a failure of the dam.

Stability analyses were performed for both the overflow and non-overflow sections for the anticipated range of loading conditions. A review of the results indicates that the resultant of forces is located outside the middle third of the base width for 50 percent of the PMF, PMF and normal pool with ice loading conditions.

Based on visual observations, review of the information provided by the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, and conversations with the Owner's representative, Crum Creek Dam appears to be in good condition.

Recommendations and Remedial Measures are as follows:

a. Facilities.

1. The spillway capacity should be increased in accordance with the results of further hydrologic and hydraulic studies.

2. Recommendations for remedial strengthening of the dam will depend on a review of the further detailed hydrologic and hydraulic studies and in-depth stability analyses. This work is to be done by a licensed professional engineer experienced in the design and construction of dams.

3. The stem on the downstream reservoir drain valve should be repaired or replaced.

b. Operation and Maintenance Procedures

1. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored and downstream residents should be alerted in the event of an impending failure.

2. The Owner should have the facility inspected by an experienced professional engineer on an annual basis.

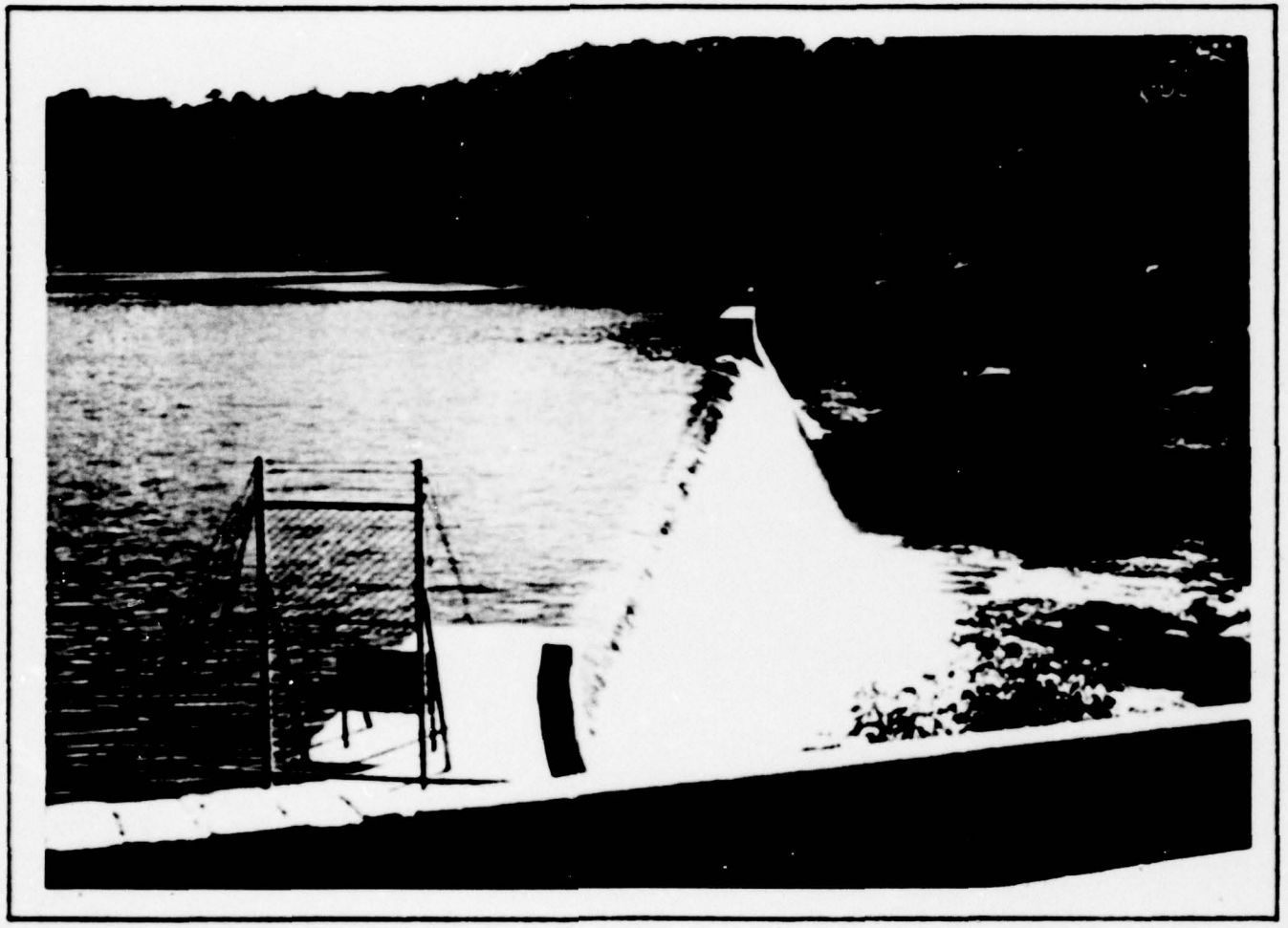
O'BRIEN & GERE ENGINEERS, INC.
JUSTIN & COURTNEY DIVISION

John J. Williams Date: 5 Sept 1979

John J. Williams, P.E.
Vice President
Pennsylvania Registration PE006920E

Approved by: James W. Peck Date: 19 Sep 1979

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



OVERVIEW
CRUM CREEK DAM, DELAWARE COUNTY, PENNSYLVANIA

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(Continued)

PLATES

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CRUM CREEK DAM ID #PA00350

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose of Inspection. The purpose of this inspection is to determine if Crum Creek Dam constitutes a hazard to human life or property.

1.2 Description of Project (Based upon information provided by the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, Pennsylvania)

a. Dam and Appurtenances. Crum Creek Dam is a masonry gravity structure (cyclopean concrete construction) with a total length of about 610 feet and a height of about 25 feet at its maximum section. The dam extends approximately 470 feet from the right abutment (south abutment) across Crum Creek; from this point the axis alignment is changed (approximately 30^{o} in the downstream direction) and the dam continues to the left abutment.

The non-overflow section of the dam is constructed to Elevation 117.0. The upstream face is sloped at one horizontal to 20 vertical (1H:20V), the downstream slope is vertical above Elevation 108.5 and sloped at 2H:3V below this elevation. The crest of the non-overflow section of the dam is about four feet wide.

The overflow section is 210 feet long and is constructed as an uncontrolled Ogee spillway. It is located about 80 feet from the right abutment. The control section of the spillway is a formed concrete cap constructed to Elevation 112.0.

The dam creates a reservoir with a storage capacity at normal pool of about 282 acre-feet. The impoundment is used as a water supply reservoir for the Owner's distribution system.

The intake structure is located about 400 feet from the right abutment. A 36-inch diameter pipe (terra cotta) extends from the intake structure through the non-overflow section, and is used to divert water to a chamber located about 140 feet downstream of the dam.

b. Location. Crum Creek Dam is located on Crum Creek about one mile northeast of Media, Pennsylvania, in Nether Providence and Springfield Townships,

Delaware County. The dam site is shown on the USGS "Lansdowne, Pennsylvania" Quadrangle at coordinates N 39° 55.5', W 75° 22.0'. A regional vicinity map of Crum Creek Dam is included as Plate 1, Appendix E.

c. Size Classification. Crum Creek Dam has a maximum height of 25 feet and an estimated maximum storage capacity of 670 acre-feet. The structure is classified in the "Small" size category.

d. Hazard Classification. Several manufacturing businesses are located approximately 0.5 miles downstream of Crum Creek Dam. A failure of the dam could possibly result in loss of life and extensive property damage. The structure is classified in the "High" hazard category.

e. Ownership. Crum Creek Dam is owned by the Philadelphia Suburban Water Company, 762 Lancaster Avenue, Bryn Mawr, PA 19010.

f. Purpose of Dam. The dam was constructed to form a water supply reservoir for the Owner's water distribution system.

g. Design and Construction History. Crum Creek Dam was designed by George S. Beal, Division Engineer for the Water Supply Commission of Pennsylvania and was constructed by the Andrew O'Neill Company of Philadelphia, PA. Construction started in September 1918 and was completed in 1920. The original Owner of the dam was the Springfield Consolidated Water Company which later was reorganized as the Phildelphia Suburban Water Company.

A review of the correspondence indicates that the original intake pipe (36-inch diameter terra cotta) was partially replaced by a 36-inch cast iron pipe between 1930 and 1937. There is no record of any additional modifications made to the dam.

Failure of the road embankment, approximately 50 feet downstream of the right abutment, was reported to have occurred in 1959. This failure apparently did not affect the structure.

h. Normal Operating Procedures. According to the Owner's representative, Mr. Thomas Kiely, the reservoir water surface is normally maintained at or near the spillway crest. Releases are made from Geist Storage Reservoir (located about 3 miles upstream) to supplement normal runoff to Crum Creek Dam.

The average quantity of water diverted to the distribution system from Crum Creek Reservoir is about 20 mgd. The sluice gate on the 36-inch diameter line is positioned to meet this demand.

1.3 Pertinent Data

a.	Drainage Area. (square miles)	29.1
b.	Discharge at Dam Site. (cfs)	
	Maximum Flood of Record (Elevation 115.0) (Tropical Storm Agnes, June, 1972)	3,928

	Maximum Spillway Capacity	8,452

c. Elevation. (feet above MSL)

Top of Dam	117.0
Spillway Crest (Normal Pool)	112.0
Streambed at Downstream Toe of Dam	92±
Invert, Water Supply Pipe	101.3

d. Reservoir Length. (feet)

Normal Pool, Elev. 112.0	4,000
Top of Dam, Elev. 117.0	5,000

e. Storage. (acre-feet)

Normal Pool, Elev. 112.0		282
Top of Dam, Elev. 117.0	(Estimated)	670

f. Surface Area. (acres)

Normal Pool, Elev. 112.0		27.5
Top of Dam, Elev. 117.0	(Estimated)	128

g. Dam Data.

Type	Masonry gravity (cyclopeon concrete)
Length	610 feet
Height	25feet (maximum)
Top Width	4 feet
Side Slopes	1H:20V (upstream 2H:3V (downstream) vertical above Elev. 108.5
Zoning	N/A
Impervious Core	N/A
Cutoff	The structure is keyed into the rock foundation.
Grout Curtain	A single line of holes on 8-foot centers (25 feet deep) was grouted under pressures up to 60 psi.
Drain System	A French drain system was constructed in the dam foundation.

h. Spillway.

Type	Ogee masonry gravity (cyclopeon concrete)
Length of Weir	210 feet

Crest Elevation	112.0
Gates	None
Upstream Channel	None
Downstream Channel	Crum Creek (natural streambed)

i. Regulating Outlets. A 36-inch diameter terra cotta and cast iron pipe extends from the intake structure to a chamber below the dam. 36-inch diameter valves are positioned on the line upstream and downstream of the dam.

A reservoir drain system (24-inch diameter) is constructed through the dam. Two 24-inch diameter valves are positioned in series downstream of the dam.

A 20-inch diameter cast iron pipeline extends from the reservoir to the water treatment facility and is used to flush the coagulating basin at the treatment facility. 20-inch diameter valves are positioned upstream and downstream of the dam.

SECTION 2

ENGINEERING DATA

2.1 Design

a. Data Available. The engineering data provided by DER for review of Crum Creek Dam includes the following:

1. "Permit, "Application", and "Report Upon the Application" to construct Crum Creek Dam, 1918.

2. Original spillway discharge capacity calculations.

3. Construction Contract and Specifications.

4. Construction progress reports and photographs.

5. Periodic inspection reports and photographs (reports dated 1920, 1925, 1930, 1937, 1947, 1959, and 1970).

6. Miscellaneous correspondence and memoranda.

b. Design Features. The design features are described in Section 1.2.a and are shown in Appendix E, Plates 2 and 3.

2.2 Construction

Based on the field investigation and the information available in the construction reports, the dam appears to have been constructed in general conformance with the design drawings.

2.3 Operation

According to the Owner's representative, daily operation consists of positioning of the 36-inch sluice gate at the intake. The operation of this gate regulates the quantity of flow to the water supply system.

2.4 Evaluation

a. Availability. The information utilized in this report was provided by the Pennsylvania DER.

b. Adequacy. A limited quantity of design calculations and drawings were provided by DER. However, this information in conjunction with observations made in the field investigation and discussions with the Owner's representative, Mr. Thomas Kiely, is considered adequate for a Phase I investigation.

c. Validity. It appears that there is no reason to question the validity of the data obtained from DER.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. Crum Creek Dam was inspected on June 13, 1979. At the time of the inspection, the reservoir water surface elevation was about 0.3 feet above the spillway crest (Elevation 112.3). No underwater areas were inspected. The observations and comments recorded by the field inspection team are presented in Appendix B.

b. Dam. The non-overflow section of the dam appears to be in good condition. The entire structure has recently been surfaced with gunite. No open cracks or indications of seepage were noted in any visible portions of the dam. Horizontal and vertical alignment appear to be in the as-constructed condition; no evidence of structural displacement was detected. Rock outcrops are evident in the vicinity of the right abutment. No seepage was noted in either of the abutment areas.

The overflow section of the dam is an Ogee spillway. The control section (crest) appears to be a formed concrete cap. The downstream slope is surfaced with rubble masonry; the masonry has recently been protected with a gunite coating. The spillway crest shows no evidence of horizontal or vertical displacement. A thorough inspection of the crest and downstream face of the spillway was prevented due to the flow conditions.

The dam foundation was not visible at the time of inspection. However, there is no evidence of foundation deterioration. Due to the flow conditions, the existence and effectiveness of the foundation drain system could not be verified.

c. Appurtenances. The intake structure is located on the left side of the dam in the non-overflow section. The structure and operating mechanisms appear to be well maintained. No trash was accumulated on the trashrack at the time of inspection. Flow into the intake is regulated by a 36-inch circular sluice gate. The gate is normally positioned to permit maximum inflow. Flow is conveyed from the intake to the gatehouse in a 36-inch diameter pipe. Two pipes in parallel, one 30-inch diameter and one 36-inch diameter, extend from the gatehouse to a water treatment facility located about 400 feet downstream of the dam.

A 24-inch diameter pipe is located through the base of the right non-overflow section of the dam; this pipe is used as a reservoir drain. A second pipe, a 20-inch diameter vitrified clay pipe, is used to provide water to the treatment plant to periodically (about twice a year) flush the coagulating basin. According to operating personnel, all valves and pipelines are operational except for one of the two valves located on the downstream side of the reservoir drain. The stem is bent and complete functioning of the valve is doubtful.

d. Reservoir. The slopes adjacent to the reservoir range from 10 to 40 percent and are well vegetated. There is no evidence of slope instability. A training wall (about 5 feet high) constructed upstream of the right abutment has failed for a length of about fifty feet. The exposed embankment appears to be stable.

e. Downstream Channel. The stilling basin was not visible at the time of inspection. However, deposits of gravel were noted downstream of the dam.

The channel below the dam is generally between 30 to 40 feet wide; the channel banks are about 4 feet high. The banks are vegetated with slopes of about 2H:1V.

A highway bridge is located about 500 feet downstream of the dam. The flow area available through this structure is about 15 feet (high) by 75 feet (wide).

Several manufacturing businesses are located approximately 0.5 miles downstream of the dam.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures

The Philadelphia Suburban Water Company operates the Crum Creek facility as a water supply reservoir. About 20 mgd is diverted from the impoundment to the water distribution system. Operating personnel attend the facility on a daily basis.

4.2 Maintenance of the Dam

The dam is maintained by the Philadelphia Suburban Water Company. According to the Owner's representative maintenance is performed on an "as required" basis.

4.3 Maintenance of Operating Facilities

The operating facilities are maintained by the Philadelphia Suburban Water Company. According to the Owner's representative, maintenance is performed on an "as required" basis.

4.4 Description of any Warning System in Effect

No formal warning system or procedures are established for monitoring the structure during periods of heavy rain or in the event of impending dam failure. However, it is reported that the Owner is presently engaged in planning meetings with County Civil Defense representatives to develop a formal warning system.

4.5 Evaluation of Operational Adequacy

The operation and maintenance procedures for Crum Creek Dam are considered to be adequate. Records of performed maintenance, however, should be maintained. Upon completion and acceptance of the formal warning system, operating personnel should be familiarized with the procedures for alerting downstream residents and appropriate agencies during periods of anticipated high volume flows. Procedures for evacuation should also be included in this plan.

It appears that the dam is accessible under all weather conditions for inspection and emergency action.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features

a. Design Data. Design information is limited to data submitted with the Dam Application Report dated August 3, 1918 and consists of stage-discharge-storage relationships and drainage area computations.

The computed drainage area contributing to Crum Creek Dam is 29.1 square miles. However, runoff from about 21.5 square miles of this watershed is controlled by Geist Storage Dam (NDI No. PA00348) located about 3 miles upstream. Ground elevations within the drainage area range from about 550 feet to 112.0 feet (MSL) at the normal pool. The watershed is about equally proportioned in urbanization, woodlands and open fields. The runoff characteristics of the watershed may undergo change in the future as a result of further urbanization.

The design capacity for the impoundment at normal pool (Elevation 112.0) is 282 acre-feet. The maximum theoretical spillway discharge at the maximum reservoir stage (Elevation 117.0) is 8,452 cfs.

b. Experience Data. No rainfall or reservoir water surface elevations are recorded for this dam. However, the Owner's representative stated that the maximum water surface elevation observed at the dam site occurred during Tropical Storm Agnes (June, 1972) when the reservoir water surface was approximately 3 feet above the spillway crest. This corresponds to a spillway discharge of approximately 3,900 cfs.

c. Visual Observations. On the date of inspection, there were no indications that the spillway would not perform as designed.

d. Overtopping Potential. Crum Creek Dam is classified as a "Small" size, "High" hazard dam. Accordingly, the Spillway Design Flood (SDF) ranges from fifty percent of the PMF to the PMF. In view of potential high hazard to loss of life in the event of a dam failure, the PMF was selected as the appropriate SDF.

The PMF was developed and routed through the facility (starting water surface elevation at the spillway crest) using the HEC-1 Computer Program, Dam Safety Version. The computer model included the hydraulic effect of Geist Storage Dam on Crum Creek Dam.

The PMF peak inflow and outflow are 46,331 and 46,303 cfs, respectively; the resulting reservoir stage is 123.99 MSL. Further review of the results indicates that the spillway can adequately pass about 23 percent of the PMF prior to overtopping the non-overflow portions of the dam. Refer to Appendix C for the computer input and output.

e. Spillway Adequacy. In view of the unfavorable results of the stability analyses (Refer to Section 6.1.f), a dam break analysis was performed to evaluate the increased "hazard to loss of life downstream from the dam from that which would exist just before failure" (ETL 1110-2-234, 10 May 1978).

A review of the analysis indicates that failure of Crum Creek Dam would increase the maximum depth of flow at the hazard area from 12.9 feet to 14.2 feet for thirty percent of the PMF, an increase in the depth of flow of about 10 percent. The peak discharge at the hazard area would increase from 11,656 cfs to 16,778 cfs for 30 percent of the PMF. Failure of Crum Creek Dam is not considered to significantly increase the hazard to loss of life or property damage.

The spillway is classified as "Inadequate" for discharging the SDF. It is not classified as "Seriously Inadequate" because failure of the dam would not significantly increase the hazard for loss of life or property damage even though the spillway is capable of passing only 23 percent of the PMF.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. No deficiencies which might affect the structural integrity of the dam were noted during the visual inspection. A complete inspection of the dam was not possible due to flow conditions at the time of inspection. The existence and effectiveness of the foundation drain system could not be verified.

b. Design and Construction Data. All available material provided by DER was reviewed. A listing of this information is presented in Section 2.1.a.

A report and analyses of the structural stability of the spillway section were provided by DER. This information was reviewed and was found to agree closely with the analyses performed herein for the one similiar loading condition (normal pool with full uplift). A summary of the stability data provided by DER is included in Appendix G.

c. Operating Records. No operating records relative to recorded water surface elevations or ice depth were available. However, according to the Owner's representative, the maximum water surface elevation observed was about 3 feet above the spillway crest. This corresponds to an Elevation of 115.0. The tailwater elevation at this time was not recorded.

d. Post-Construction Changes. According to information provided by DER, no modifications have been made to the dam. The visual inspection revealed that the structure has been recently gunited.

e. Seismic Stability. The dam is located in Seismic Zone 1 as shown on the "Seismic Zone Map of Contiguous States". Unless geological abnormalities exist at this site, a dam located in this zone can be considered stable for seismic loading if it can be demonstrated that the dam is stable for the design loading conditions. No adverse geological conditions are known to exist for this location, however, static seismic stability analyses have been conducted in view of the results obtained for design loadings.

f. Evaluation. Stability analyses were performed for the spillway and non-overflow sections of the dam.

An examination of the results of the analyses indicates that stability requirements relative to overturning are not met for normal pool with ice, PMF and fifty percent of the PMF loading conditions. The resultant of forces for these conditions is located outside the middle third of the base width. Criteria outlined in the Recommended Guidelines for Safety Inspection of Dams require that the resultant of forces fall within the middle third of the base width.

A summary of the results of the stability analyses are presented in Appendix G. The assumptions and calculations are also included in Appendix G.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety. A review of the results of the visual inspection of the dam and appurtenances, and of the material provided by DER indicates that the structure appears to be in good condition and was constructed in general compliance with the drawings. A recent surfacing treatment prevented a visual inspection of the structural condition of the dam.

Minor scouring of the channel below the spillway was noted; however, this condition is not considered detrimental to the stability of the dam.

Based on a review of the results of the hydrologic and hydraulic calculations, the spillway is capable of passing about 23 percent of the PMF without overtopping of the dam. However, the increased hazard due to a dam breach does not significantly increase the potential for loss of life or property damage. Therefore, the spillway is classified as "Inadequate", but not "Seriously Inadequate".

The resultant of forces is not located in the middle third of the base width (spillway and non-overflow sections) for fifty percent of the PMF, PMF and normal pool with ice loading conditions. Tension is developed in the upstream face of the dam for these loading situations.

b. Adequacy of Information. The information made available by DER, conversations with the Owner's representative and visual observations are considered adequate to make a Phase I evaluation of the dam.

c. Urgency. The recommendations presented in Section 7.2 should be implemented as soon as possible.

d. Necessity for Further Investigation. Further detailed hydrologic and hydraulic studies should be made to determine the extent to which the spillway capacity needs to be increased. In-depth stability analyses should be performed to determine if remedial measures are necessary.

7.2 Recommendations and Remedial Measures

a. Facilities.

1. The spillway capacity should be increased in accordance with the results of further hydrologic and hydraulic studies.

2. Recommendations for remedial strengthening of the dam will depend on a review of the further detailed hydrologic and hydraulic

studies and in-depth stability analyses. This work is to be done by a licensed professional engineer experienced in the design and construction of dams.

3. The stem on the downstream reservoir drain valve should be repaired or replaced.

b. Operation and Maintenance Procedures.

1. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored and downstream residents should be alerted in the event of an impending failure.

2. The Owner should have the facility inspected by an experienced professional engineer on an annual basis.

APPENDIX

A

Check List Engineering Data

Design, Construction, Operation

Phase I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Crum Creek Dam

ID # PA 00350

ITEM	REMARKS
AS-BUILT DRAWINGS	No "as-built" drawings are available.
REGIONAL VICINITY MAP	Refer to Appendix E, Plate 1.
CONSTRUCTION HISTORY	Available information relative to construction history was provided by DER. Refer to Section 1.2.g.
TYPICAL SECTIONS OF DAM	Refer to Appendix E, Plate 3 for available drawings.
OUTLETS - PLAN	Refer to Appendix E for available drawings.
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	Refer to Appendix C.
RAINFALL/RESERVOIR RECORDS	

ITEM	REMARKS
DESIGN REPORTS	Design reports are limited to a design summary made by personnel of The Water Supply Commission, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
GEOLOGY REPORTS	Geology reports are limited to a summary made by personnel of The Water Supply Commission, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Computations are limited to a summary made by personnel of The Water Supply Commision, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Refer to Appendix E, Plate 3.
POST-CONSTRUCTION SURVEYS OF DAM	None recorded
BORROW SOURCES	N/A

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Portions of the original 36-inch terracotta water supply pipe have been replaced with cast iron pipe.
HIGH POOL RECORDS	The maximum reservoir surface elevation observed is approximately 115.0 during Tropical Storm Agnes, June, 1972.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	The dam was last inspected and a report prepared and published in March, 1976. The firm engaged for the inspection was Woodward-Clyde Consultants.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None recorded.
MAINTENANCE OPERATION RECORDS	None recorded.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Refer to Appendix E, Plate 3.
OPERATING EQUIPMENT PLANS & DETAILS	Refer to Appendix E, Plate 3.
MISCELLANEOUS	

APPENDIX

B

Check List

Visual Inspection

Phase I

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam Crum Creek Dam County Delaware State Pennsylvania National ID # PA 00350

Type of Dam Masonry Gravity (cyclopeon concrete) Hazard Category High

Date(s) Inspection June 13, 1979 Weather Clear Temperature 52° F

Pool Elevation at Time of Inspection 112.3 ± M.S.L. Tailwater at Time of Inspection 92 ± M.S.L.

Inspection Personnel:

Mr. John J. Williams

Mr. Leonard R. Beck

Mr. Robert R. Bowers

Mr. Robert R. Bowers Recorder

Remarks:

The inspection team was accompanied by Mr. T. M. Kiely, Design Engineer, Philadelphia Suburban Water Company and Richard Bateman, Manager of the water treatment facility

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	No seepage was observed	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	No deficiencies noted	
DRAINS	Existance of the foundation drainage system shown on the drawing could not be verified during the inspection.	
WATER PASSAGES	Not observed	
FOUNDATION	Not observed	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	None noted. The entire structure has been recently surfaced with gunite.	
STRUCTURAL CRACKING	None observed	
VERTICAL AND HORIZONTAL ALIGNMENT	Vertical and horizontal alignment appear to be good.	
MONOLITH JOINTS	No joints were visible due to the recent gunite surfacing treatment	
CONSTRUCTION JOINTS	No joints were visible due to the recent gunite surfacing treatment	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	N/A	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	N/A	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No erosion at the abutments was observed	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	N/A	
RIPRAP FAILURES	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The training wall upstream of the right abutment has failed for a lenth of about 50 feet. The bank is exposed, however, the slope of bank is moderate and appears to be stable.	This area should be visually inspected periodically to detect the development of any further adverse conditions.
ANY NOTICEABLE SEEPAGE	N/A	
STAFF GAGE AND RECORDER	None	
DRAINS	N/A	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	No deficiencies noted in those portions visible.	
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	N/A	
EMERGENCY GATE	According to the Owner's representative, a stem on one of the two downstream control valves is bent.	The valve stem should be repaired or replaced

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	No problems observed. Entire spillway section has recently been surfaced with gunite.	
APPROACH CHANNEL	None	
DISCHARGE CHANNEL	Slight scour and gravel deposits are evident at the downstream toe of the spillway section.	This area should be visually inspected periodically to detect the development of any further adverse conditions.
BRIDGE AND PIERS	None	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes adjacent to the reservoir are relatively mild and well vegetated. However, the slope adjacent to the right abutment is formed in a steep rock cut. The exposed rock slope appears to be stable.	
SEDIMENTATION	None observed.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The downstream channel narrows from a 200-foot width below the spillway to about a 40-foot width, 500 feet downstream of the dam. A highway bridge (Beatty Road) is also located about 500-feet below the dam. The bridge opening is 75-feet wide by 15-feet high.	
SLOPES	The overbanks of Crum Creek (downstream of the dam) are relatively flat and well vegetated.	
APPROXIMATE NO. OF HOMES AND POPULATION	The nearest downstream damage center is a small industrial complex. Approximately 100 people are employed within this facility.	

APPENDIX

C

Hydrologic & Hydraulic Data

TABLE OF CONTENTS - APPENDIX C

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	1	RRB	4/20/79	

HYDROLOGY CALCS.

DRAINAGE AREAS (PLANIMETERED ON USGS QUAD SHEET)

FULL DRAWAGE BASIN: 29.1 $mi.^2$

GEIST RESERVOIR SUB-BASIN: 21.7 $mi.^2$
CRUM CREEK DAM SUB-BASIN: 7.4 $mi.^2$

PMP CALCULATIONS (HMR 33)

AREA IS IN ZONE 6

24 HR., 200 SQ. MI. RAINFALL = 23.5"

HR	%	RAINFALL	ARF
6	103	24.2"	24.2"
12	112	26.3"	2.1"
24	122	28.7"	2.4"
48	134	31.5"	2.8"

SNYDER COEFFICIENTS

FROM INFO. PROVIDED BY COE FOR THE DELAWARE RIVER BASIN, ZONE 10:

$\boxed{C_p = 0.60}$

AND $C_t = 1.25$

$t_p = C_t (L \cdot L_{ca})^{0.3}$

GEIST

$L = 10.2$ mi. $L_{ca} = 5.7$ mi.

$t_p = 1.25 (10.2 \cdot 5.7)^{0.3} = \boxed{4.23 \text{ HR.}}$

CRUM CREEK DAM

$L = 4.5$ mi. $L_{ca} = 2.1$ mi.

$t_p = 1.25 (4.5 \cdot 2.1)^{0.3} = \boxed{2.45 \text{ HR.}}$

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	2	RRB	4/20/79	

GEIST RESERVOIR ROUTING

(INFORMATION OBTAINED FROM BALT. COE PHASE I INSPECTION REPORT BY WOODWARD-CLYDE CONSULTANTS)

STAGE	STORAGE (ACRE-FEET)
125 (ORIGINAL STREAMBED ELEVATION)	0
200	10,740
207	13,577
220 *	20,100

* - ELEVATION 220 CONTOUR WAS PLANIMETERED ON USGS QUAD SHEET AS 550 ACRES, WHICH WAS CONVERTED TO STORAGE BY THE CONIC METHOD.

STAGE-DISCHARGE INFORMATION IS OBTAINED FROM THE ORIGINAL CHANNEL CAPACITY CURVE FOR THE GEIST DAM SPILLWAY ON SHEET 4, APPENDIX C OF THE ABOVE MENTIONED REPORT.

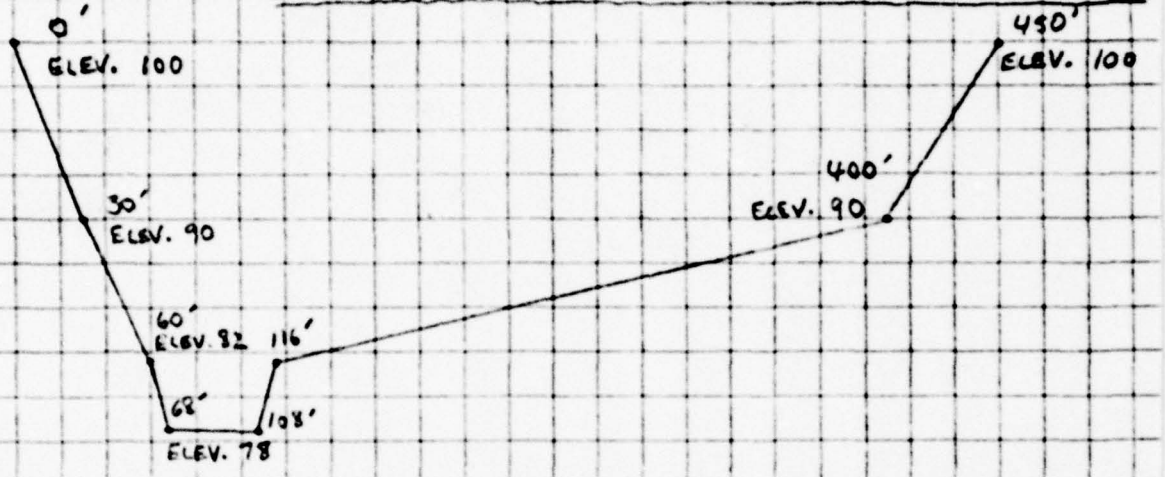
STAGE	DISCHARGE (CFS)
200	0
201	1100
202	3100
203	5700
204	8500
205	10,100
206	11,300
207	12,100
208	12,900
210	13,700

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	3	RRB	4/20/82	

DOWNSTREAM CROSS-SECTION FOR HEC-1 DAM BREAK ANALYSIS

APPROX. 0.5 MILES DOWNSTREAM FROM THE DAM



Stage-Storage Information from DER Files

Stage (Ft above MSL)	Storage (Millions of Gallons)	Storage (Ac. Ft.)
103	2.22	6.8
104	4.52	13.9
105	7.13	21.9
106	11.33	34.8
107	18.53	56.9
108	28.53	87.7
109	40.93	125.8
110	55.63	171.0
111	72.53	222.9
112	91.98	282.7
113	113.68	349.4
114	137.08	421.3
115	162.18	498.4
117	218.0	670
125	553.2	1700

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********

     1          A1                          NATIONAL DAM INSPECTION PROGRAM
     2          A2                                CRUM CREEK DAM
     3          A3                                PMF HYDROGRAPH
     4          W    300       0      30       0       0       0       0       0      -4       0
     5          W1     5
     6          J      1       9       1
     7          J1    .2      .3      .4      .5      .6      .7      .8      .9     1.0
     8          K      0   IN-GST                                                1
     9          K1                              RUNOFF TO GEIST RESERVOIR
    10          M      1       1    21.7            29.1                                1
    11          P      0    23.5     103     112     122     134
    12          T                                                     1.0    0.05
    13          W   0.23    0.60
    14          R   -1.5    -.05       2
    15          K      1   OUT-GT                                                1
    16          K1                            ROUTING THROUGH GEIST RESERVOIR
    17          Y                                   1       1
    18          Y1     1                                                  -200      -1
    19          Y4   200     201     202     203     204     205     206     207     208     210
    20          Y5     0    1100    3100    5700    8500   10100   11300   12100   12800   13700
    21          Y6     0   10740   13577   20100
    22          YE   125     200     257     220
    23          YS   200
    24          YU   207     3.1     1.5    2000
    25          K      0   IN-CRM                                                1
    26          K1                              RUNOFF TO CRUM CREEK LAKE
    27          M      1       1     7.4            29.1                                1
    28          P      0    23.5     103     112     122     134
    29          T                                                     1.0    0.05
    30          W   2.45    0.60
    31          R   -1.5    -.05       2
    32          K      2   COMBIN                                                1
    33          K1                  COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR
    34          K      1   OUT-CR                                                1
    35          K1                            ROUTING THROUGH CRUM CREEK LAKE
    36          Y                                   1       1
    37          Y1     1                                                  -117
    38          YS     0     282     670    1700
    39          YE    92     112     117     125
    40          YS   112     210     3.6     1.5
    41          YD   117     3.1     1.5     260
    42          K     99
```

Sht 4

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********

RUN  DATE= 05/01/79.
     TIME= 12.15.46.
```

NATIONAL DAM INSPECTION PROGRAM
CRUM CREEK DAM
PMF HYDROGRAPH

overtopped analysis

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	30	0	0	0	0	0	-6	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS=	.20	.30	.40	.50	.60	.70	.80	.90	1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO GEIST RESERVOIR

	ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	IN-GST	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

	IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
	1	1	21.70	0.00	29.10	0.00	0.000	0	1	0

PRECIP DATA

	SPFE	PMS	R6	R12	R24	R48	R72	R96
	0.00	23.50	103.00	112.00	122.00	134.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .834

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMS	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 4.23 CP= .90 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 49 END-OF-PERIOD ORDINATES, LAG= 4.22 HOURS, CP= .61 VOL= 1.00

76.	284.	572.	902.	1256.	1585.	1834.	1989.	2061.	1955.
1763.	1502.	1395.	1227.	1089.	964.	854.	757.	671.	595.
527.	467.	414.	367.	325.	288.	255.	226.	201.	178.
158.	140.	124.	110.	97.	86.	76.	68.	60.	53.
47.	42.	37.	33.	29.	26.	23.	20.	18.	

96

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.28	23.81	2.46	677633.
										(667.)(	605.)(	63.)(19182.77)

HYDROGRAPH ROUTING

ROUTING THROUGH GEIST RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT-GT	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSK*	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-200.	-1

STAGE	200.00	201.00	202.00	203.00	204.00	205.00	206.00	207.00	208.00	210.00
FLOW	0.00	1100.00	3100.00	5700.00	8500.00	10100.00	11300.00	12100.00	12800.00	13700.00
CAPACITY=	0.	10760.	13577.	20100.						
ELEVATION=	125.	200.	207.	220.						

CHEL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
207.0	3.1	1.5	2000.

PEAK OUTFLOW IS 5964. AT TIME 45.50 HOURS

PEAK OUTFLOW IS 8028. AT TIME 45.50 HOURS

PEAK OUTFLOW IS 10949. AT TIME 46.00 HOURS

PEAK OUTFLOW IS 13841. AT TIME 46.00 HOURS

PEAK OUTFLOW IS 14901. AT TIME 45.00 HOURS

PEAK OUTFLOW IS 23025. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 27040. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 30679. AT TIME 44.50 HOURS

96

PEAK OUTFLOW IS 34194. AT TIME 40.50 HOURS

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO CRUM CREEK LAKE

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
IN-CRM		0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	7.40	0.00	29.10	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	103.00	112.00	122.00	134.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .834

LOSS DATA

LRUPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00**********		0.00

UNIT HYDROGRAPH DATA

TP= 2.45 CP= .60 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 29 END-OF-PERIOD ORDINATES, LAG= 2.45 HOURS, CP= .60 VOL= 1.00

97.	352.	698.	997.	1169.	1165.	973.	787.	637.	515.
417.	337.	273.	221.	179.	145.	117.	95.	77.	62.
50.	41.	33.	27.	21.	17.	14.	11.	9.	

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP 0	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP 0
									SUM	26.28	26.28	0.00	258896.
										(667.)(	667.)(	0.)(	7331.12)

COMBINE HYDROGRAPHS

COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
COMBIN		2	0	0	0	0	1	0	0

HYDROGRAPH ROUTING

ROUTING THROUGH CRUM CREEK LAKE

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT-CR	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-112.	0

CAPACITY=	0.	282.	670.	1700.
ELEVATION=	92.	112.	117.	125.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
112.0	210.0	3.6	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
117.0	3.1	1.5	760.

PEAK OUTFLOW IS 7552. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 11656. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 14963. AT TIME 44.00 HOURS

PEAK OUTFLOW IS 17913. AT TIME 43.50 HOURS

PEAK OUTFLOW IS 23947. AT TIME 45.00 HOURS

PEAK OUTFLOW IS 29994. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 35586. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 41880. AT TIME 44.00 HOURS

PEAK OUTFLOW IS 46303. AT TIME 44.00 HOURS

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 .70	RATIO 7 .80	RATIO 8 .90	RATIO 9 1.00
HYDROGRAPH AT	IN-GST	21.70	1	5954.	10430.	13907.	17384.	20861.	24338.	27816.	31291.	34768.
		(56.20)		(168.90)(	265.36)(	393.81)(	492.26)(	590.71)(	689.16)(	787.62)(	886.07)(	984.52)
ROUTED TO	OUT-GT	21.70	1	5864.	8828.	10989.	13861.	18901.	23025.	27048.	30679.	34196.
		(56.20)		(166.04)(	249.97)(	311.17)(	391.92)(	535.23)(	652.01)(	765.68)(	868.73)(	968.25)
HYDROGRAPH AT	IN-CRK	7.60	1	3367.	5051.	6735.	8418.	10102.	11786.	13470.	15153.	16837.
		(19.17)		(95.35)(	143.03)(	190.71)(	238.38)(	286.06)(	333.74)(	381.41)(	429.09)(	476.77)
2 COMBINED	COMBIN	29.10	1	7599.	11765.	15018.	17979.	24097.	30167.	35961.	41224.	46331.
		(75.37)		(215.18)(	332.58)(	425.26)(	509.10)(	682.36)(	854.23)(	1018.29)(	1167.34)(	1311.96)
ROUTED TO	OUT-CR	29.10	1	7552.	11656.	14963.	17913.	23987.	29996.	35586.	41088.	46303.
		(75.37)		(213.85)(	330.07)(	423.70)(	507.23)(	679.23)(	849.34)(	1007.69)(	1163.27)(	1311.15)

SUMMARY OF DAM SAFETY ANALYSIS

Geist Storage Reservoir

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	200.00	200.00	207.00
STORAGE	10740.	10740.	13577.
OUTFLOW	0.	0.	12100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	203.06	0.00	11480.	5864.	0.00	45.50	0.00
.30	204.20	0.00	12446.	8828.	0.00	45.50	0.00
.40	205.74	0.00	13867.	10989.	0.00	46.00	0.00
.50	207.38	.38	13769.	13841.	2.50	46.00	0.00
.60	207.99	.99	14074.	18901.	4.50	45.00	0.00
.70	208.39	1.39	14275.	23025.	6.50	44.50	0.00
.80	208.72	1.72	14441.	27040.	7.50	44.50	0.00
.90	209.00	2.00	14580.	30679.	8.00	44.50	0.00
1.00	209.25	2.25	14705.	34194.	9.00	44.50	0.00

SUMMARY OF DAM SAFETY ANALYSIS

Crum Creek Dam

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	112.00	112.00	117.00
STORAGE	282.	282.	670.
OUTFLOW	0.	0.	8452.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	116.64	0.00	642.	7552.	0.00	44.50	0.00
.30	117.93	.93	790.	11656.	6.00	44.50	0.00
.40	118.71	1.71	891.	14963.	9.00	44.00	0.00
.50	119.34	2.34	971.	17913.	11.00	43.50	0.00
.60	120.50	3.50	1120.	23987.	12.50	45.00	0.00
.70	121.53	4.53	1253.	29996.	13.50	44.50	0.00
.80	122.42	5.42	1368.	35586.	14.50	44.50	0.00
.90	123.24	6.24	1474.	41088.	15.50	44.00	0.00
1.00	123.99	6.99	1570.	46303.	16.00	44.00	0.00

11 1/6

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 197A
  LAST MODIFICATION  26 FEB 79
**********
     1              A1
     2              A2                          NATIONAL DAM INSPECTION PROGRAM
     3              A3                                  CRUM CREEK DAM
     4              R     300       0      30       0       0       0       0       0      -4       0
     5              R1      5
     6              J       2       1       1
     7              J1    0.3
     8              K       0  IN-GST                                                1
     9              K1                          RUNOFF TO GEIST RESERVOIR
    10              M       1       1    21.7            29.1                                   1
    11              P       0    23.5     103     112     122     134
    12              T                                                    1.0    0.05
    13              W    4.23    0.60
    14              X   -1.5    -.05       2
    15              K       1  OUT-GT                                                1
    16              K1                          ROUTING THROUGH GEIST RESERVOIR
    17              Y                                       1       1
    18              Y1      1                                                   -200      -1
    19              Y4    200     201     202     203     204     205     206     207     208     210
    20              YS      0    1100    3100    5700    8500   10100   11300   12100   12800   13700
    21              SS      0   10740   13577   20100
    22              SF    125     200     207     220
    23              SS    200
    24              SD    207     3.1     1.5    2000
    25              K       0  IN-CRM                                                1
    26              K1                          RUNOFF TO CRUM CREEK LAKE
    27              M       1       1     7.4            29.1                                   1
    28              P       0    23.5     103     112     122     134
    29              T                                                    1.0    0.05
    30              W    2.45    0.60
    31              X   -1.5    -.05       2
    32              K       2  COMBIN                                                1
    33              K1                  COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR
    34              K       1  OUT-CR                                                1
    35              K1                          ROUTING THROUGH CRUM CREEK LAKE
    36              Y                                       1       1
    37              Y1      1                                                   -112
    38              SS      0     282     670    1700
    39              SF     92     112     117     125
    40              SS    112     210     3.6     1.5
    41              SD    117     3.1     1.5     260
    42              SA    100       0      97       2     112     125
    43              SA    100       0      97       2     112   117.5
    44              K       1  HAZARD                                                1
    45              K1                          ROUTING DOWNSTREAM TO DAMAGE CENTER
    46              Y                                       1       1
    47              Y1      1                                                     -1
    48              YA    .07     .04     .05      78      95    6000    .002
    49              YT      0     100      30      90      60      82      68      78     108      78
    50              YT    116      82     400      90     450     100
    51              K      99
```
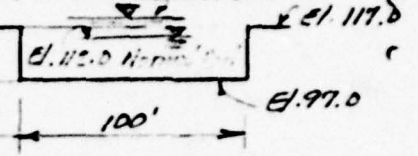

Dam Break Analysis

El. 117.5, Assumed Reservoir stage when Breach occurs



The portion of the dam assumed to be breached is based on the geometry of the site. The depth of flow over the top of the dam at which failure is initiated and the elapsed time to complete failure are based on the general [illegible] recommendations given in the C.O.E. publication "Basic Concepts of Dam Breach and Development of Dam Break Hydrographs"

12

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 07/31/79.
     TIME= 13.15.52.
```

Dam Breach Analysis

NATIONAL DAM INSPECTION PROGRAM
CRUM CREEK DAM
PMF HYDROGRAPH

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	30	0	0	0	0	0	-4	0

JOPER	NVT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= .30

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO GEIST RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
IN-GST		0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	21.70	0.00	29.10	0.00	0.000	0	1	0

PRECIP DATA

	SPFE	PMS	R6	R12	R24	R48	R72	R96
	0.00	23.50	103.00	112.00	122.00	134.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .834

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 4.23 CP= .60 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 49 END-OF-PERIOD ORDINATES, LAG= 4.22 HOURS, CP= .61 VOL= 1.00

76.	284.	572.	902.	1256.	1585.	1836.	1989.	2061.	1955.
1763.	1562.	1385.	1227.	1088.	964.	854.	757.	671.	595.
527.	467.	414.	367.	325.	288.	255.	226.	201.	178.
158.	140.	124.	110.	97.	86.	76.	68.	60.	53.
47.	42.	37.	33.	29.	26.	23.	20.	18.	

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.28	23.81	2.46	677633.
										(667.)	(605.)	(63.)	(19182.77)

HYDROGRAPH ROUTING

ROUTING THROUGH REIST RESERVOIR

Dam Break Analysis

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	OUT-GT	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-200.	-1

STAGE	200.00	201.00	202.00	203.00	204.00	205.00	206.00	207.00	208.00	210.00
FLOW	0.00	1100.00	3100.00	5700.00	8500.00	10100.00	11300.00	12100.00	12800.00	13700.00
CAPACITY=	0.	10740.	13577.	20100.						
ELEVATION=	125.	200.	207.	220.						

CREL	SPWID	COOV	EXPW	ELEVL	COOL	CAREA	EXPL
200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
207.0	3.1	1.5	2000.

PEAK OUTFLOW IS 8828. AT TIME 45.50 HOURS

PEAK OUTFLOW IS 8828. AT TIME 45.50 HOURS

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO CRUM CREEK LAKE

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	IN-CRM	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	7.40	0.00	29.10	0.00	0.000	0	1	0

11-4

PRECIP DATA

SPFF	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	103.00	112.00	122.00	134.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .934

Dam Breach Analysis

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	**********	0.00

UNIT HYDROGRAPH DATA

TP= 2.45 CP= .60 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 29 END-OF-PERIOD ORDINATES. LAG= 2.45 HOURS. CP= .60 VOL= 1.00

97.	352.	690.	997.	1169.	1145.	973.	787.	637.	515.
417.	337.	273.	221.	179.	145.	117.	95.	77.	62.
50.	41.	33.	27.	21.	17.	14.	11.	9.	

END-OF-PERIOD FLOW

0 MO,DA	HR,MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO,DA	HR,MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.28	26.28	0.00	258896.
										(667.1)	(667.1)	0.1)	(7331.12)

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

COMBINE HYDROGRAPHS

COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
COMBIN		2	0	0	0	0	1	0	0

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

HYDROGRAPH ROUTING

ROUTING THROUGH CRUM CREEK LAKE

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT-CR		1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-112.	0

CAPACITY=	0.	282.	670.	1700.
ELEVATION=	92.	112.	117.	125.

GT #3

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
112.0	210.0	3.6	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
117.0	3.1	1.5	260.

DAM BREACH DATA

BRWID	Z	FLRW	TFAIL	WSEL	FAILFL
100.	0.00	97.00	2.00	112.00	125.00

PEAK OUTFLOW IS 11656. AT TIME 44.50 HOURS

Dam Break Analysis

DAM BREACH DATA

BRWID	Z	FLRW	TFAIL	WSEL	FAILFL
100.	0.00	97.00	2.00	112.00	117.50

BEGIN DAM FAILURE AT 43.00 HOURS

PEAK OUTFLOW IS 16778. AT TIME 44.92 HOURS

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

HYDROGRAPH ROUTING

ROUTING DOWNSTREAM TO DAMAGE CENTER

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
HAZARD	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	FLNVT	FLMAX	RLNTH	SEL
.0700	.0400	.0500	78.0	95.0	6000.	.00200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00	100.00	30.00	90.00	60.00	82.00	68.00	78.00	100.00	78.00	
116.00	82.00	400.00	90.00	450.00	100.00					

STORAGE	0.00	5.15	10.76	16.77	23.25	30.71	42.06	57.75	77.76	102.10
	130.77	163.77	201.09	242.75	288.13	336.69	387.13	438.46	479.66	529.75
OUTFLOW	0.00	55.88	179.53	357.74	586.59	884.76	1281.94	1796.88	2455.16	3279.87
	4289.86	5504.19	6947.52	8621.29	10708.33	13131.28	15802.72	18708.02	21861.76	25199.67

97 of 116

STAGE	78.00	78.89	79.79	80.68	81.58	82.47	83.37	84.26	85.16	86.05
	86.95	87.84	88.74	89.63	90.53	91.42	92.32	93.21	94.11	95.00
FLOW	0.00	55.88	179.53	357.74	588.59	886.76	1281.96	1796.88	2455.16	3279.87
	4289.06	5504.19	6942.52	8621.29	10700.33	13131.20	15802.72	18788.87	21841.76	25199.67

MAXIMUM STAGE IS 98.0

MAXIMUM STAGE IS 92.2

Dam Break Analysis

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

LT 48

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS 1 .30
HYDROGRAPH AT	IN-GST	21.70	1	10430.
		(56.20)		(295.36)(
			2	10430.
				(295.36)(
ROUTED TO	OUT-GT	21.70	1	8828.
		(56.20)		(249.97)(
			2	8828.
				(249.97)(
HYDROGRAPH AT	IN-CRW	7.40	1	5051.
		(19.17)		(143.03)(
			2	5051.
				(143.03)(
2 COMBINED	COMBIN	29.10	1	11745.
		(75.37)		(332.58)(
			2	11745.
				(332.58)(
ROUTED TO	OUT-CR	29.10	1	11656.
		(75.37)		(330.07)(
			2	15707.
				(444.78)(
ROUTED TO	HAZARD	29.10	1	11593.
		(75.37)		(328.28)(
			2	15529.
				(439.73)(

Dam Breach Analysis

SH 15

SUMMARY OF DAM SAFETY ANALYSIS

Crum Creek Dam

Dam Break Analysis

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	112.00	112.00	117.00
STORAGE	282.	282.	670.
OUTFLOW	0.	0.	8452.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.30	117.93	.93	790.	11456.	0.00	44.50	0.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	112.00	112.00	117.00
STORAGE	282.	282.	670.
OUTFLOW	0.	0.	8452.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.30	117.42	.42	749.	14778.	1.71	44.92	43.00

PLAN 1 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.30	11593.	98.0	44.50

PLAN 2 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.30	15529.	92.2	45.00

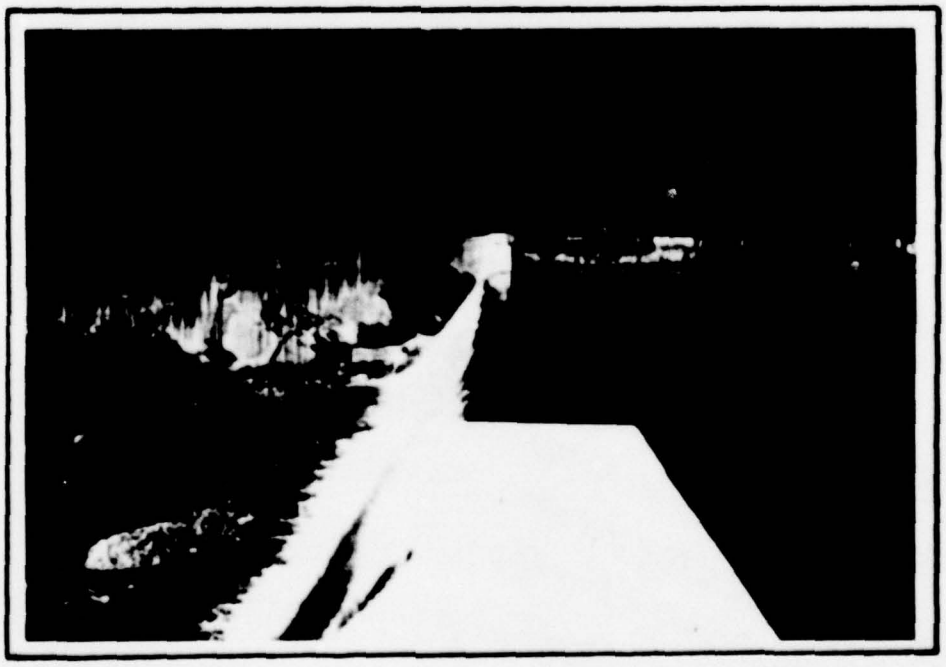
ET 48

APPENDIX

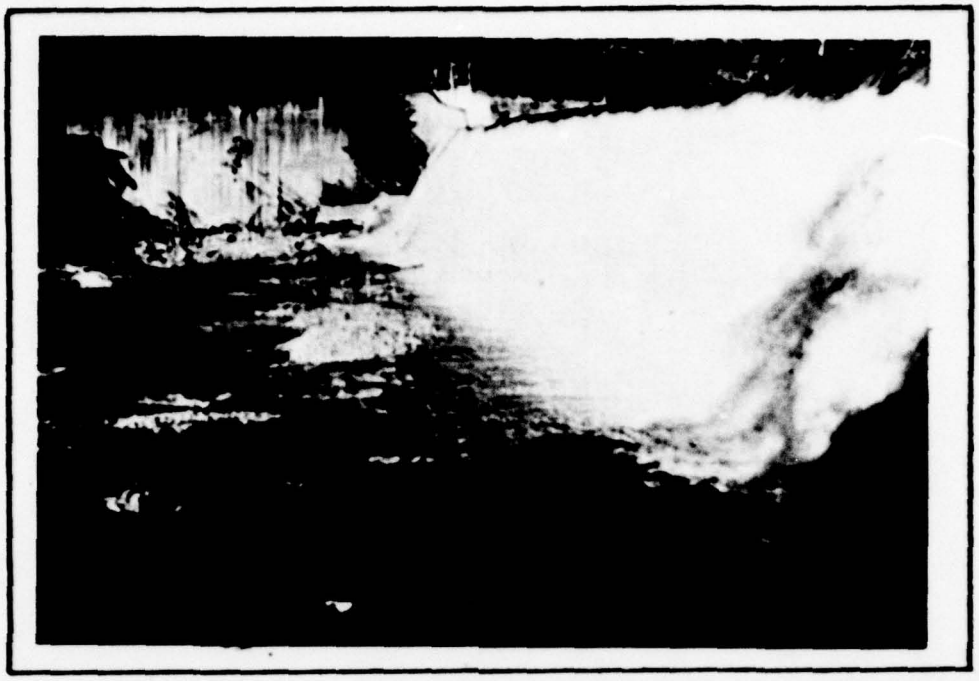
D

Photographs

INLET GATE SYSTEM
HOIST AND TRASH
GUARD



VIEW OF THE SPILLWAY LOOKING
TOWARDS THE RIGHT ABUTMENT



VIEW OF THE SPILLWAY LOOKING TOWARDS THE RIGHT ABUTMENT AS SEEN FROM THE DOWNSTREAM TOE OF THE DAM

HIGHWAY BRIDGE ABOUT 500 FEET DOWNSTREAM OF THE DAM

VIEW ABOUT 1,000 FEET DOWNSTREAM OF THE DAM LOOKING UPSTREAM AT THE PHILADELPHIA SUBURBAN WATER COMPANY'S WATER TREATMENT PLANT

POTENTIAL DAMAGE AREA APPROXIMATELY 2,000 YARDS DOWNSTREAM OF THE DAM

APPENDIX

E

Drawings

TABLE OF CONTENTS - APPENDIX E

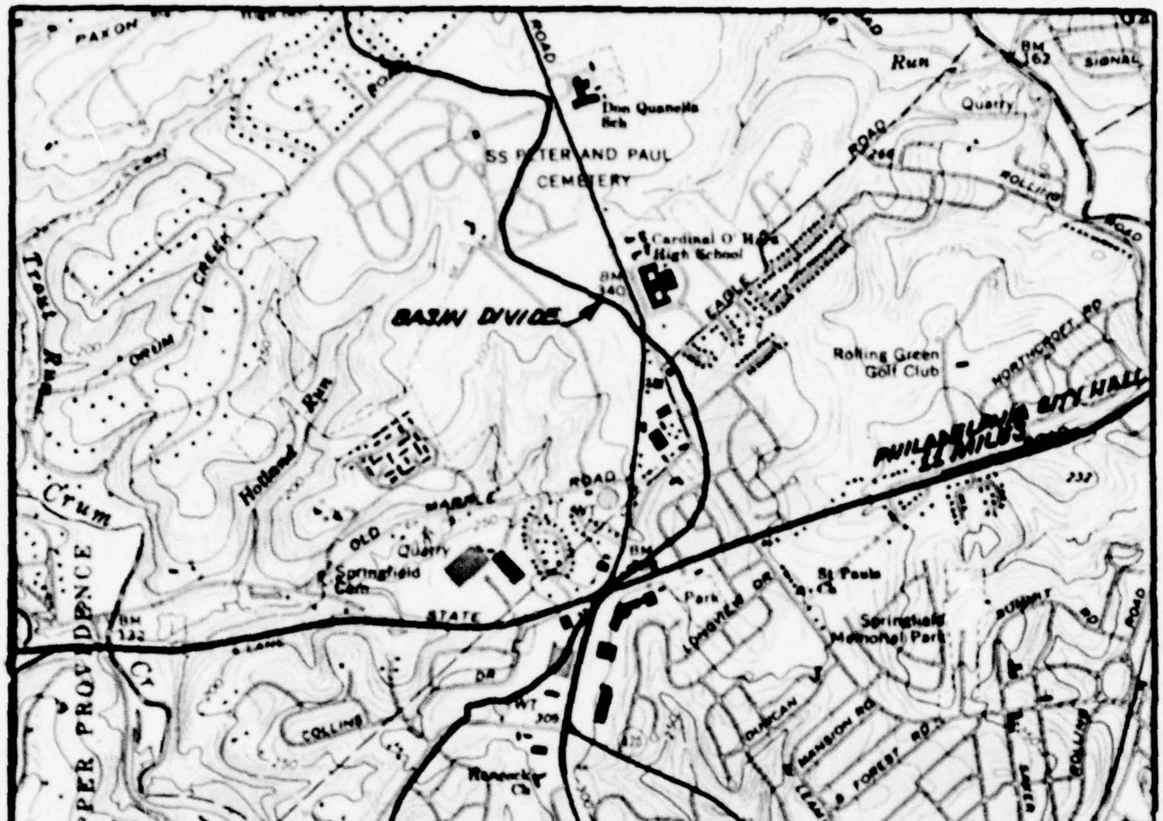
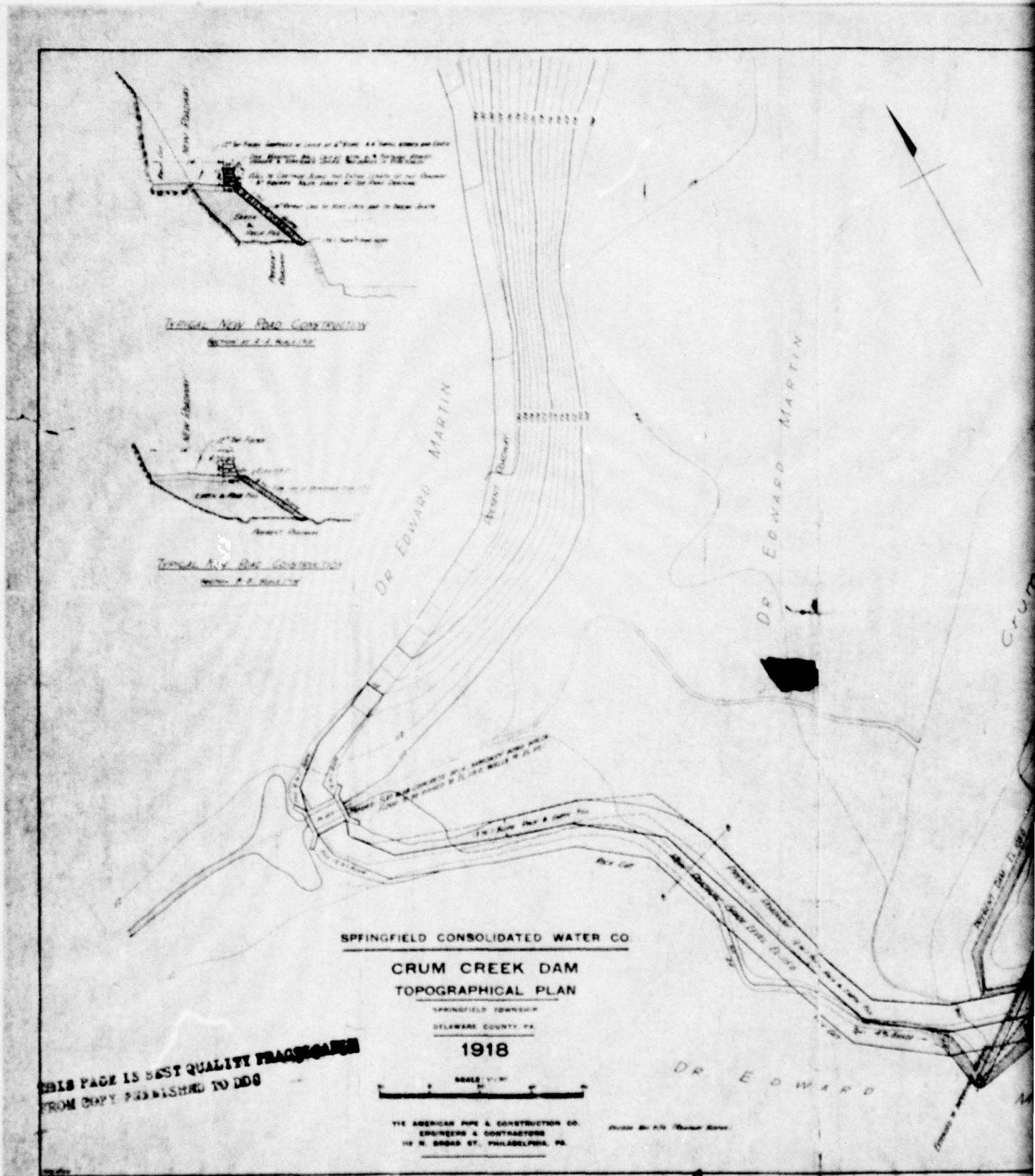
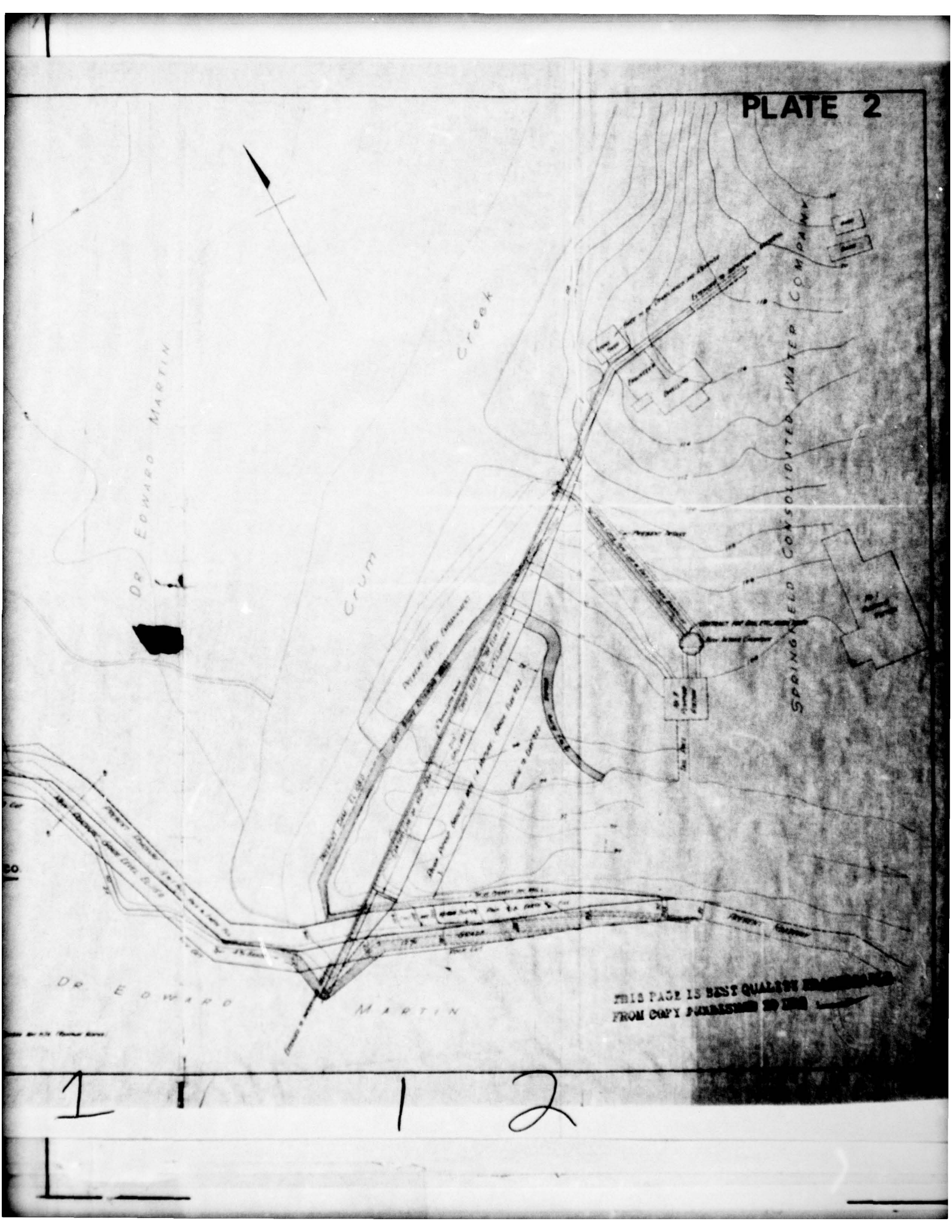


PLATE 1
REGIONAL VICINITY MAP
SCALE 1:24000
N

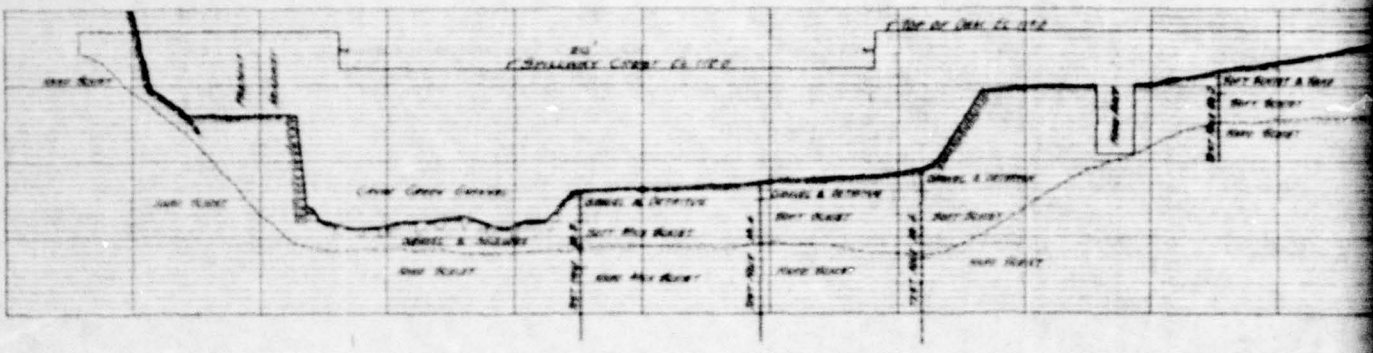


1

PLATE 2

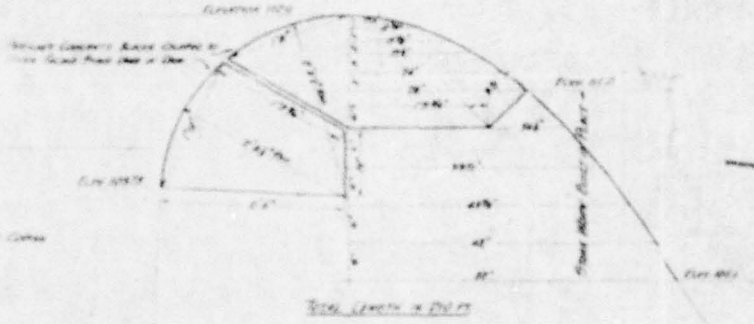


1 1 2



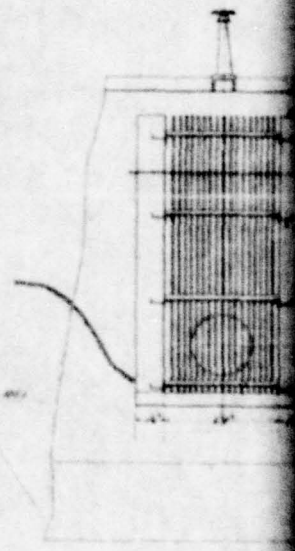
PROFILE ALONG CENTRE LINE OF DAM LOOKING UP-STREAM

SCALE HORIZONTAL AND VERTICAL ONE



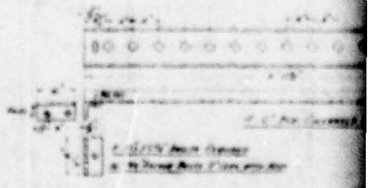
TOTAL LENGTH X FEET

DETAIL OF SPILLWAY COPING



FRONT ELEVATION

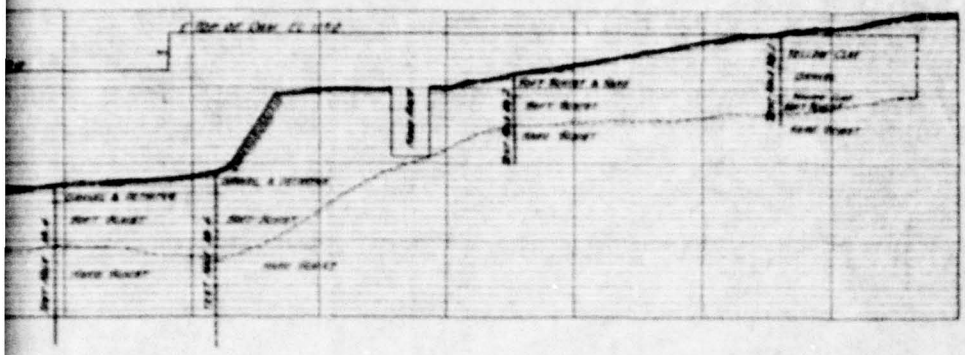
TYPICAL CROSS SECTION THROUGH SPILLWAY

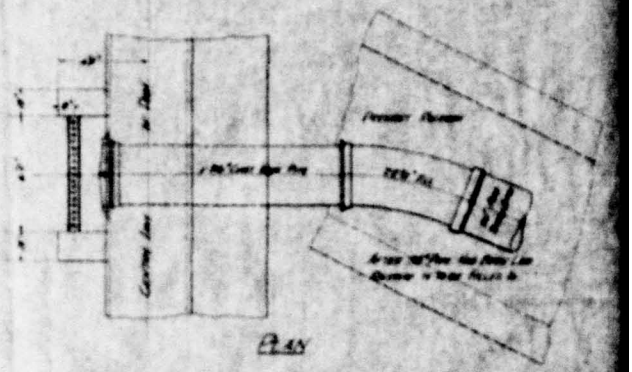


DETAIL OF RISER PIPE

1

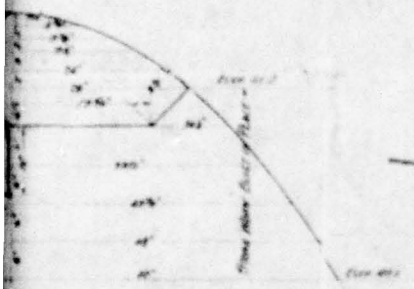
PLATE 3



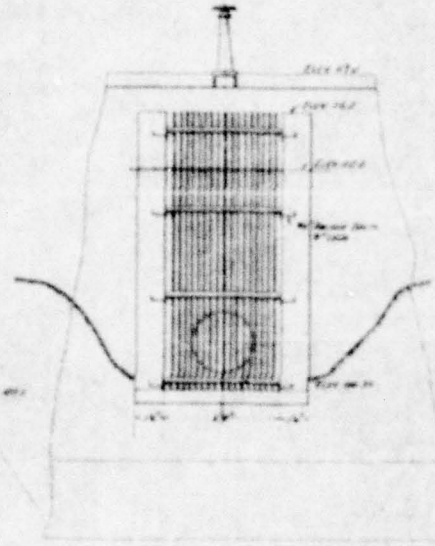


PLAN

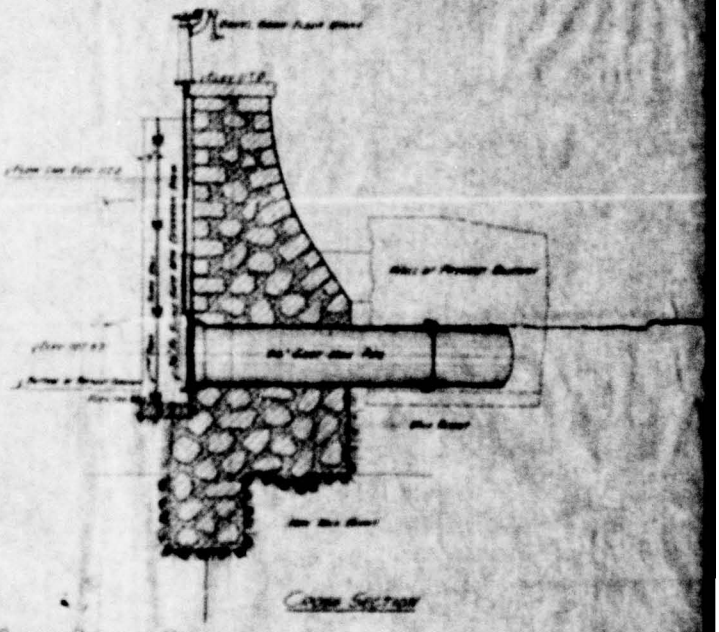
...E OF DAM LOOKING UP-STREAM



...SPILLWAY CREST

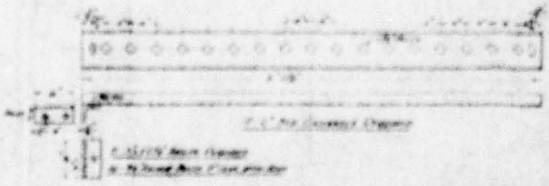


FRONT ELEVATION



CROSS SECTION

DETAIL OF OUTLET PIPE AND PRISM



DETAIL OF IRON FOR TIMBER PRISM

SPRINGFIELD CONSOLIDATED WATER CO.

CRUM CREEK DAM

PROFILE, SECTIONS AND DETAILS

SPRINGFIELD TOWNSHIP, DELAWARE COUNTY, PA.

1918

SCALE: 1" = 10'

THE AMERICAN BRIDGE & CONSTRUCTION CO.
ENGINEERS & CONTRACTORS
NO. 6 BROAD ST., PHILADELPHIA, PA.

1 1 2

O'BRIEN & GERE ENGINEERS, INC.

SUBJECT	SHEET	BY	DATE	JOB NO
Crum Creek Dam	4	[illegible]	8/27/79	

APPENDIX

F

Site Geology

SITE GEOLOGY

CRUM CREEK DAM

Crum Creek is located in the Uplands section of the Piedmont physiographic province. The structure was constructed upon a shallow stratum of unconsolidated stream alluvium. The underlying bedrock consists of mica schist which is a unit of the Paleozoic Wissahickon formation. No faults or major structural defects are noted in the vicinity of the dam or reservoir.

PLATE 1
REGIONAL GEOLOGY MAP
SCALE 1:24000

APPENDIX

G

Structural Stability Data

TABLE OF CONTENTS - APPENDIX G

O'BRIEN & GERE

CRUM CREEK DAM	SHEET 1	BY REH	DATE	JOB NO

- ORIGINAL DESIGN CALCULATIONS - SUMMARY

LOADING CONDITION	RESULTANT LOCATION	SLIDING SAFETY FACTOR
WSE = 117.0, No Uplift Base Elev. - 100.0 Base Width - 12.9'	5.23'	.55 = $\Sigma H / \Sigma V$
Reservoir Empty Base Elev. - 100.0 Base Width - 12.9'	4.98'	N/A
WSE = 117.0, No Uplift Base Elev. - 87.0 Base Width - 22.0'	8.53'	.57
WSE = 117.0, Uplift Base Elev. - 87.0 Base Width - 22.0'	8.28'	.67
Reservoir Empty Base Elev - 87.0 Base Width - 22.0'	8.04'	N/A

Information provided by DER

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	2	REH		

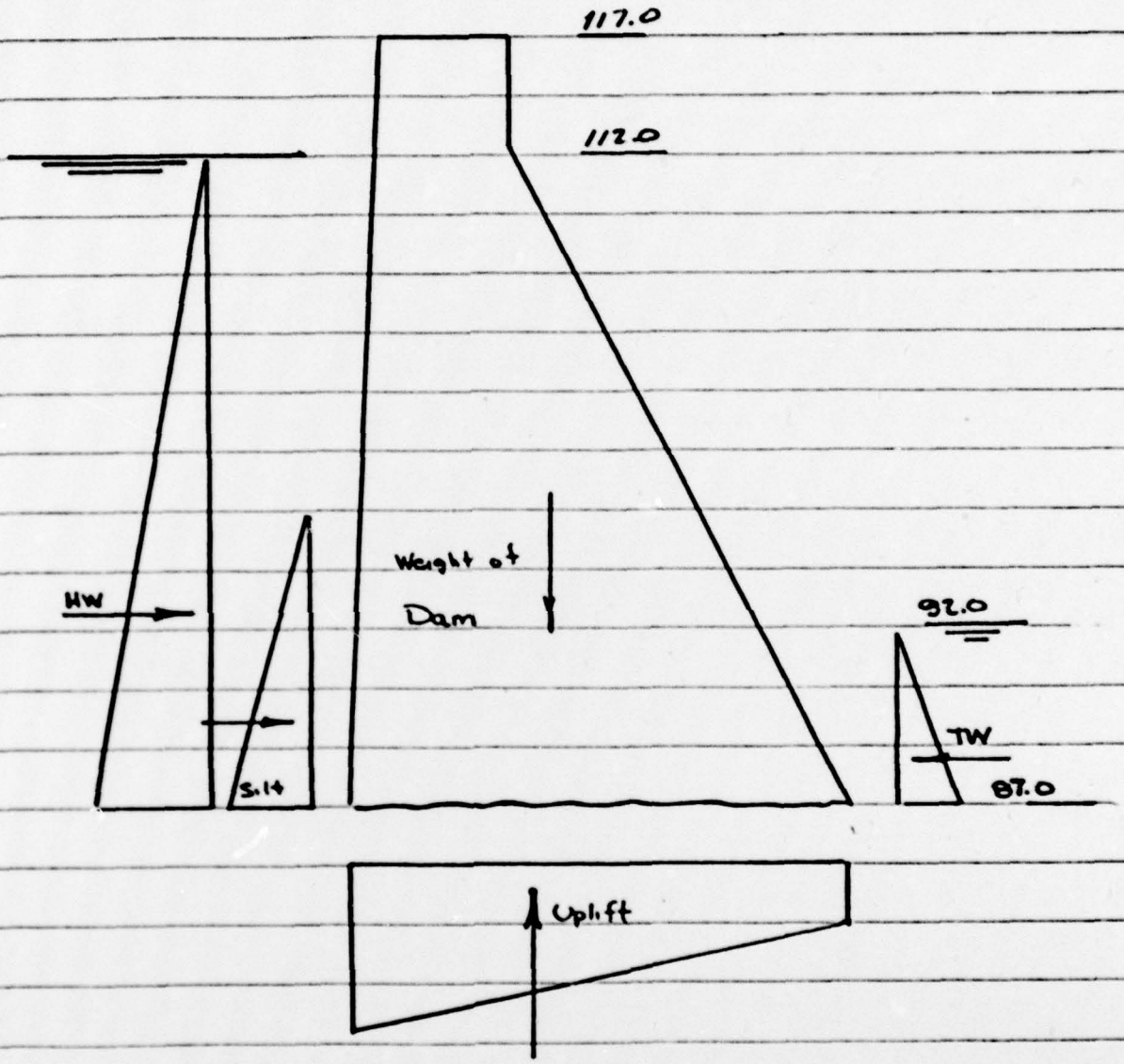
— ASSUMPTIONS FOR STABILITY ANALYSES —

— MASONRY DENSITY	145 PCF
— SILT DENSITY, SUBMERGED	60 PCF
— EARTH PRESSURE COEFFICIENT	0.33
— SHEAR RESISTANCE AT DAM/FOUNDATION INTERFACE	50 PSI
— COEFFICIENT OF FRICTION AT DAM/FOUNDATION INTERFACE	0.60
— ICE PRESSURE (ONE FOOT THICK)	5,000 PSF
— EARTHQUAKE ACCELERATION	0.025 g

— ANY STABILIZING EFFECTS DUE TO PASSIVE EARTH PRESSURES HAVE NOT BEEN CONSIDERED

O'BRIEN & GERE

PROJECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	3	REH		



— LOADING DIAGRAM FOR NORMAL POOL —

O'BRIEN & GERE

JECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	4	REH		

STABILITY ANALYSES SUMMARY — NON-OVERFLOW SECTION

LOADING CONDITION	RESULTANT LOCATION[1]	BASE PRESSURES - PSI -	SAFETY FACTORS: over-turning	SAFETY FACTORS: sliding
Normal Pool W.S.E. = 112.0	9.2	14.28 4.58	1.6	8.5
Normal Pool with Ice load	5.96	23.05 - 3.76	1.3	7.3
PMF W.S.E = 124.0	- 13.38	28.93 - 21.33	.8	5.2
½ PMF W.S.E. = 119.3	0.28	21.33 - 10.46	1.0	6.4
Normal Pool with Earthquake	8.57	15.88 2.98	1.5	7.8

[1] Resultant Location - Distance in feet from toe of dam

Base Width = 22.2 ft.

O'BRIEN & GERE

JECT	SHEET	BY	DATE	JOB NO
CRUM CREEK DAM	5	REH		

STABILITY ANALYSES SUMMARY – SPILLWAY SECTION

LOADING CONDITION	RESULTANT LOCATION[1]	BASE PRESSURES – PSI –	SAFETY FACTORS: OVERTURNING	SAFETY FACTORS: SLIDING
Normal Pool W.S.E. = 112.0	7.76	15.64 .80	1.4	8.4
Normal Pool with Ice Load	4.1	24.41 – 7.54	1.2	7.2
PMF W.S.E = 124.0	– 18.73	23.45 – 18.28	.8	5.6
½ PMF W.S.E. = 119.3	– 2.08	19.26 – 10.82	1.0	6.7
Normal Pool with Earthquake	7.14	17.02 – .58	1.4	7.7

[1] Resultant Location – Distance in feet from toe of dam

Base Width = 22.2 ft.

CRUM CREEK DAM NON-OVERFLOW SECTION
NORMAL POOL - ELEV. 112.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)+.000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	
HEADWATER	19.50	8.32		162.34
TAILWATER	.78	1.66	1.30	
UPLIFT	20.78	13.57		281.90
SILT	2.25	5.00		11.24
			732.83	455.48

NET HORIZONTAL FORCE= 20.97 KIPS
NET VERTICAL FORCE= 30.15 KIPS
NET MOMENT= 277.35KIP-FEET
X-BAR OF FOUNDATION REACTION= 9.20 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 1.90 FEET
FOUNDATION REACTION PRESSURES TOE= 14.28 PSI HEEL= 4.58 PSI
OVERTURNING FACTOR OF SAFETY= 1.61
SLIDING FACTOR OF SAFETY= .86
DEVELOPED FRICTION FACTOR (NO SHEAR)= .70
SLIDING WITH SHEAR FACTOR OF SAFETY= 8.49(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM NON-OVERFLOW SECTION
NORMAL POOL WITH ICE LOAD

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 111.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION000.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	
HEADWATER	17.97	7.99		143.63
TAILWATER	.78	1.66	1.30	
UPLIFT	20.09	13.52		271.65
SILT	2.25	5.00		11.24
ICE LOAD	5.00	24.50		122.50
			732.83	549.02

NET HORIZONTAL FORCE= 24.44 KIPS
NET VERTICAL FORCE= 30.84 KIPS
NET MOMENT= 183.82KIP-FEET
X-BAR OF FOUNDATION REACTION= 5.96 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 5.14 FEET
0000000000FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE00000TENSION AT HEEL OF DAM00000
FOUNDATION REACTION PRESSURES0000000TOE= 23.05 PSI0000000HEEL= -3.76 PSI0000000
OVERTURNING FACTOR OF SAFETY= 1.33
SLIDING FACTOR OF SAFETY= .76
DEVELOPED FRICTION FACTOR (NO SHEAR)= .79
SLIDING WITH SHEAR FACTOR OF SAFETY= 7.30(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM NON-OVERFLOW SECTION
PROBABLE MAXIMUM FLOOD - ELEV. 124.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 124.00FT. TAILWATER ELEVATION= 106.00FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	
HEADWATER	41.10	11.59		477.36
TAILWATER	11.26	6.33	71.26	
UPLIFT	38.79	12.29		476.67
SILT	2.25	5.00		11.24
			802.80	965.27

NET HORIZONTAL FORCE= 32.17 KIPS
NET VERTICAL FORCE= 12.14 KIPS
NET MOMENT= -162.48KIP-FEET
X-BAR OF FOUNDATION REACTION= -13.38 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 24.48 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE******TENSION AT HEEL OF DAM******
FOUNDATION REACTION PRESSURES********TOE= 28.93 FSI********HEEL= -21.33 FSI*******
OVERTURNING FACTOR OF SAFETY= .83
SLIDING FACTOR OF SAFETY= .23
DEVELOPED FRICTION FACTOR (NO SHEAR)= 2.65
SLIDING WITH SHEAR FACTOR OF SAFETY= 5.30(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM NON-OVERFLOW SECTION
ONE HALF PMF - ELEV. 119.3

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 119.30FT. TAILWATER ELEVATION= 103.15FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)+.000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	
HEADWATER	32.39	10.66		345.30
TAILWATER	8.14	5.38	43.76	
UPLIFT	33.56	12.33		413.89
SILT	2.25	5.00		11.24
			775.30	770.51

NET HORIZONTAL FORCE= 26.50 KIPS
NET VERTICAL FORCE= 17.37 KIPS
NET MOMENT= 4.79KIP-FEET
X-BAR OF FOUNDATION REACTION= .28 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 10.82 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE******TENSION AT HEEL OF DAM******
FOUNDATION REACTION PRESSURES********TOE= 21.33 PSI********HEEL= -10.46 PSI********
OVERTURNING FACTOR OF SAFETY= 1.01
SLIDING FACTOR OF SAFETY= .39
DEVELOPED FRICTION FACTOR (NO SHEAR)= 1.53
SLIDING WITH SHEAR FACTOR OF SAFETY= 6.43(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM NON-OVERFLOW SECTION
NORMAL POOL WITH EARTHQUAKE

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION=.025G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	
HEADWATER	19.50	8.32		162.34
TAILWATER	.78	1.66	1.30	
UPLIFT	20.78	13.57		281.90
EARTHQUAKE INDUCED LOADINGS				
INERTIA-WATER	.59	10.00		5.31
HORIZONTAL INERTIA-DAM	.27	10.72		13.65
SILT	2.25	5.00		11.24
			732.83	474.44

NET HORIZONTAL FORCE= 22.77 KIPS
NET VERTICAL FORCE= 30.15 KIPS
NET MOMENT= 258.40KIP-FEET
X-BAR OF FOUNDATION REACTION= 8.57 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 2.53 FEET
FOUNDATION REACTION PRESSURES=TOE= 15.98 PSI HEEL= 2.98 PSI
OVERTURNING FACTOR OF SAFETY= 1.54
SLIDING FACTOR OF SAFETY= .79
DEVELOPED FRICTION FACTOR (NO SHEAR)= .74
SLIDING WITH SHEAR FACTOR OF SAFETY= 7.01(SHEAR ACROSS FULL BASE WIDTH)
NUMBER OF STATIONS TO DESCRIBE DAM= 5

STATION	ELEVATION
.00	87.00
16.70	112.00
16.70	117.00
20.70	117.00
22.20	87.00

CRUM CREEK DAM - SPILLWAY SECTION
NORMAL POOL - ELEV. 112.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)+.000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.06	13.99	658.18	
HEADWATER	19.50	8.32		162.34
TAILWATER	.78	1.66	1.30	
UPLIFT	20.78	13.57		281.90
SILT	2.25	5.00		11.24
			659.48	455.48

NET HORIZONTAL FORCE= 20.97 KIPS
NET VERTICAL FORCE= 26.28 KIPS
NET MOMENT= 204.00KIP-FEET
X-BAR OF FOUNDATION REACTION= 7.76 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.34 FEET
FOUNDATION REACTION PRESSURES TOE= 15.64 PSI HEEL= .80 PSI
OVERTURNING FACTOR OF SAFETY= 1.45
SLIDING FACTOR OF SAFETY= .75
DEVELOPED FRICTION FACTOR (NO SHEAR)= .80
SLIDING WITH SHEAR FACTOR OF SAFETY= 8.38(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - SPILLWAY SECTION
NORMAL POOL WITH ICE LOAD

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 111.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION=.0000 (HORIZ)+.0000 (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.06	13.99	658.10	
HEADWATER	17.97	7.99		143.63
TAILWATER	.78	1.66	1.30	
UPLIFT	20.09	13.52		271.65
SILT	2.25	5.00		11.24
ICE LOAD	5.00	24.50		122.50
			659.40	549.02

NET HORIZONTAL FORCE= 24.44 KIPS
NET VERTICAL FORCE= 26.97 KIPS
NET MOMENT= 110.47KIP-FEET
X-BAR OF FOUNDATION REACTION= 4.10 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 7.00 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE******TENSION AT HEEL OF DAM******
FOUNDATION REACTION PRESSURES********TOE= 24.41 PSI********HEEL= -7.54 PSI*****
OVERTURNING FACTOR OF SAFETY= 1.20
SLIDING FACTOR OF SAFETY= .66
DEVELOPED FRICTION FACTOR (NO SHEAR)= .91
SLIDING WITH SHEAR FACTOR OF SAFETY= 7.20(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - SPILLWAY SECTION
PROBABLE MAXIMUM FLOOD - ELEV. 124.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 124.00FT. TAILWATER ELEVATION= 106.00FT. EARTHQUAKE ACCELERATION=0.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.06	13.99	658.18	
HEADWATER	38.22	10.37		396.50
TAILWATER	11.26	6.33	71.26	
UPLIFT	38.79	12.29		476.67
SILT	2.25	5.00		11.24
			729.45	884.41

NET HORIZONTAL FORCE= 29.20 KIPS
NET VERTICAL FORCE= 8.27 KIPS
NET MOMENT= -154.97KIP-FEET
X-BAR OF FOUNDATION REACTION= -18.73 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 29.83 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM******
FOUNDATION REACTION PRESSURES********TOE= 23.45 PSI********HEEL= -18.20 PSI*******
OVERTURNING FACTOR OF SAFETY= .82
SLIDING FACTOR OF SAFETY= .17
DEVELOPED FRICTION FACTOR (NO SHEAR)= 3.53
SLIDING WITH SHEAR FACTOR OF SAFETY= 5.64(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - SPILLWAY SECTION
ONE HALF PMF - ELEV. 119.3

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 119.30FT. TAILWATER ELEVATION= 103.15FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.06	13.99	658.18	
HEADWATER	30.89	9.87		304.85
TAILWATER	8.14	5.38	43.76	
UPLIFT	33.56	12.33		413.89
SILT	2.25	5.00		11.24
			701.95	729.97

NET HORIZONTAL FORCE= 25.00 KIPS
NET VERTICAL FORCE= 13.50 KIPS
NET MOMENT= -28.03KIP-FEET
X-BAR OF FOUNDATION REACTION= -2.08 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 13.18 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE******TENSION AT HEEL OF DAM******
FOUNDATION REACTION PRESSURES********TOE= 19.26 PSI********HEEL= -10.82 PSI********
OVERTURNING FACTOR OF SAFETY= .96
SLIDING FACTOR OF SAFETY= .32
DEVELOPED FRICTION FACTOR (NO SHEAR)= 1.05
SLIDING WITH SHEAR FACTOR OF SAFETY= 6.72(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - SPILLWAY SECTION
NORMAL POOL WITH EARTHQUAKE

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION=0.025G (HORIZ)..000G (VERT)
SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.06	13.99	658.18	
HEADWATER	19.50	8.32		162.34
TAILWATER	.78	1.66	1.30	
UPLIFT	20.78	13.57		281.90
EARTHQUAKE INDUCED LOADINGS				
INERTIA-WATER	.53	10.00		5.31
HORIZONTAL INERTIA-DAM	1.18	9.40		11.06
SILT	2.25	5.00		11.24
			659.48	471.86

NET HORIZONTAL FORCE= 22.68 KIPS
NET VERTICAL FORCE= 26.28 KIPS
NET MOMENT= 187.63KIP-FEET
X-BAR OF FOUNDATION REACTION= 7.14 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.96 FEET
FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE TENSION AT HEEL OF DAM
FOUNDATION REACTION PRESSURES TOE= 17.02 FSI HEEL= -.58 FSI
OVERTURNING FACTOR OF SAFETY= 1.40
SLIDING FACTOR OF SAFETY= .70
DEVELOPED FRICTION FACTOR (NO SHEAR)= .86
SLIDING WITH SHEAR FACTOR OF SAFETY= 7.74(SHEAR ACROSS FULL BASE WIDTH)
NUMBER OF STATIONS TO DESCRIBE DAM= 5

STATION	ELEVATION
.00	87.00
14.30	108.50
10.60	112.00
21.00	109.70
22.20	87.00